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ABSTRACT

This paper is concerned with the role of compressed speech in research related to auditory attention within the human information processing system. This brief review of some of the research using compressed speech shows that the primary research emphasis has been in the applied areas. It also suggests some areas where compressed speech research might provide valuable insight into the nature of attention and listening comprehension. An 89-item bibliography is appended. (RB)

THE ROLE OF COMPRESSED SPEECH IN ATTENTION RESEARCH

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THE ROLF OF COMPRESSED SPEECH

IN ATTENTION RESEARCH

There is little doubt that man can be characterized as a very complex and yet relatively efficient information processor. There also appears to be sufficient evidence to suggest that he is able to actively employ various strategies in performing complex operation on the vast amount of data input into his information processing system with a high degree of accuracy (Neisser, 1967; Broadbent, 1958, 1971; Moray, 1969; Norman, 1969; Newell & Simon, 1972; Keele, 1973). The present paper is concerned with the role of compressed speech in research related to auditory attention within the human information processing system.

OVERVIEW OF COMPRESSED SPEECH RESEARCH

Since Orr (1968) and Foulke and Sticht (1969) inventoried the results of research using compressed speech, a great deal of additional research has been added to the literature. A brief review of some of that research, as well as some older research, seems to be appropriate in the present paper.

Compressed speech is speech in which the time taken for a message to be presented has been reduced by mechanically increasing the word rate of presentation. Since the first practical method of compressing speech was developed, a number of methods and mechanical improvements have been developed (see for example Foulke, 1970; Cramer, 1971; Breuel & Levens, 1971; Qureshi & Kingma, 1971, Cramer & Talambiras, 1971).

Research on the effect of compression of speech on both the intelligibility and comprehension of the speech has provided rather unequivocal knowledge about the nature of these relationships. Garvey (1953a, b) found that compressing speech to what would be roughly equivalent to the rate of 290 wpm resulted in a 10% loss of word intelligibility. Fairbanks and Kodman (1957) compressed

speech to 13% of the original time (about 1000 wpm) and found a 50% loss in word intelligibility. More recently Foulke (1969) used RT as a means of determining intelligibility and found that between the word rates of 175 and 275 wpm there was a steady increase in discriminability, while between the word rates of 275 and 325 wpm there was a slight decrease in discriminability which leveled off betw n the rates of 325 and 425 wpm.

Comprehension of the information in a message has been found to have little relationship to increases in word rate until a rate between 275 and 300 wpm is reached. Word rates faster than 275 or 300 wpm result in definite decreases in comprehension (Fairbanks, Guttman, and Miron, 1957; Foulke, Amster, Nolan, and Bixler, 1962; Foulke & Sticht, 1967; Foulke, 1968; Reid, 1968).

The combined relationship between intelligibility and comprehension has been studied by Foulke and Sticht (1967). Their results indicated that while both intelligibility and comprehension decreased as rate of compression increased, comprehension declined more rapiedly than intelligibility. This finding was interpreted as demonstrating that comprehension requires more complex cognitive activity than does intelligibility. While the processing of information for intelligibility requires input of stimuli, short-term storage, and retrieval, the process of comprehending information requires the input of stimuli, short-term storage, rehearsal, selection and discarding of some information, long-term storage, and finally retrieval.

The differences between the intelligibility and the comprehension of information could be strongly related t the effect of the compression of the word time coupled with a decrement in the interstimulus time interval. A number of studies have demonstrated that pause time between stiumli is a significant factor in comprehension and recall (Aaronson, 1967, 1968; Aaronson,

Markowitz, & Shapiro, 1971; Lass, 1971). Overmann (1971) found that when the time lost in the process of speech compression was restored in the form of pause time, it facilitated comprehension of the material by the listeners.

Subjects appear to prefer listening at a rate faster than that of normal speech. Foulke (1966) found that blind subjects preferred a rate of about 275 wpm which is the level at which comprehension begins to decline in most studies. Foulke and Sticht (1966) found that for sighted subjects not previously exposed to compressed speech the preferred rate for listening was 207 wpm, again faster than the normal rate of speaking for most people. Lass and Prater (1973) found that subjects from a normal population preferred rates of 175 and 200 wpm over rates of 100 and 300 wpm.

Exposure to and training in the use of compressed speech does not appear to increase the comprehension of material later presented in compressed or uncompressed format even though in some studies the subjects expressed a preference for the compressed presentation (Voor & Miller, 1965; Orr, Friedman, & Williams, 1965; Foulke, 1964; Sticht, 1971; Watts, 1971; Weaver, 1972; Grumpelt & Rubin, 1972).

There is evidently a strong positive correlation between intelligence and comprehension of compressed speech with those subjects of higher intelligence doing as well with compressed speech as with normal speech up to the limits of comprehension of compressed speech. Subjects of lower intelligence tend to do better with the normal rate of presentation but not as well with the increased rates of presentation (Fairbanks, Guttman, & Miron, 1957; Sticht, 1969, 1970; Woodcock & Clark, 1968; Foulke, 1969; Sticht & Glassnapp, 1972).

There appears to be no relationship between sex and the comprehension of compressed speech (Foulke & Sticht, 1967; McCracken, 1971). Goldhaber and Weaver

(1968) did find that males scored higher than females, but there was reason to doubt the generalizability of these results.

The use of compressed speech as a persuasive tool was investigated by Wheeless (1971a, b) who found that there was no difference on measures of attitude or frequency of purchase after the message presented at the rate of normal speech (145 wpm) or three rates of compressed speech (204, 239, and 296 wpm). Subjects did, however, evaluate perceived source authoritativeness and character as lower when the message was compressed.

As can be seen from this brief review of some of the research using compressed speech, the primary research emphasis has been in what Orr (1968) termed "applied areas." Little research has been done into the use of compressed speech as a tool in the theoretical study of human information processing. The remainder of this paper will be concerned with some possible areas where compressed speech research might provide valuable insight into the nature of attention in the human information processing system.

COMPRESSED SPEECH AND ATTENTION

We have already defined compressed speech, and for the purpose of standardizing our thought processes, attention will be defined as (Moray, 1969b)

> an enquiry into what dimensions of input and output space may be selected by a human subject, what kinds of signals may be selected within such spaces, and whether such selection can be used to enhance the detectability of signals and the efficiency of information transmission by the human operator [p. 12].

The study of attention focuses on several different topic areas which were categorized by Posner and Boies (1971) as: 1) alertness or arousal (see Mackworth, 1970 and Broadbent, 1971, for thorough treatment of research in this area); 2) selection (see Broadbent, 1958, 1971; Triesman, 1969; Moray, 1969b); and 3) processing capacity (see Broadbent 1958, 1971). A significant body of

research has been undertaken in all three areas, but as Moray (1969a) has suggested, there is a definite need for research which relates the several areas to one another:

It might be well, for example, that the relation between selective listening and arousal is such that arousal level acts as a parameter which will alter the over-all efficiency of selection and rejection as it varies. But no systematic investigation has so far been carried out [p. 85].

Since 1969 some such research has been done (see Posner and Boies, 1971, for example), but it is still very little when compared to the entire body of attention research.

Now, what has research using compressed speech added to our knowledge of attention in human information processing? Regretfully, our answer must be "relatively little."

First, in the area of arousal Michel-Miller (1970) studied the effects of several levels of speech compression (175, 250, 325 wpm) on physiological arousal. No relationship was found between an increase in word rate and heart rate activation. Subject preferences for slightly faster-than-normal speech rate (Foulke, 1966; Foulke & Sticht, 1966; Lass & Prater, 1973) might be related to arousal, but such a relationship would seem at best to be questionable.

Second, what about selection? Triesman (1971) found that digits presented alternately to the two ears is more difficult than when the digits are presented successively to both ears. The relative difficulty of the task increased with faster rates-of-presentation which was interpreted as support that selection is more a problem of input selection than retrieval selection. Aaronson, Markowitz, and Shapiro (1971) found that when digit sequences were compressed, recall was better for the compressed digits and RT was faster. One possible explanation offered was that since compressed speech differs from normal acoustic stimuli, subjects might attend more closely to the compressed speech resulting

in the shorter RT's and better recall.

Finally, the most complete research topic is processing capacity. One area which has been studied is the relationship between stimulus duration and subsequent retrieval of the information. Based on studies of the effect of compressed words on intelligibility noted earlier in this paper, we know that deleting segments of the word does not interfere with intelligibility until a fairly significant portion of the word has been deleted. Studies of the effect of rate-of-presentation of information on recall have often found, however, that better recall is obtained when the rate-of-presentation is slower (Shaffer & Hardwick, 1969; Gerver, 1969; Triesman, 1971; Aaronson, 1967). There is evidently more than word intelligibility which enters into the processing of the data.

The important variable appears to be the duration of pauses between words within sentences and between sentences rather than the duration of words. Studies have found that compressing the speech segments of a message while retaining or expanding the pause segments results in increased performance on recall or comprehension tasks (Lass, 1971; Overmann, 1971; Aaronson, Markowitz, & Shapiro, 1971; Aaronson, 1974b). These results suggest that time available for processing the data into a form available for storage and later retrieval may be more important than the stimulus duration itself.

Holding, Foulke, and Heise (1973) performed two experiments using compressed digit sequences to test Neisser's (1967) theory that "echoic storage" may be available for several seconds before decaying. The rate-of-presentation was compressed to .5 second for six-digit lists and 1 second for twelve-digit lists. As expected, recall for twelve-digit lists was poorer. Subjects hearing the first half of the digits in the right ear recalled better than subjects receiving the digits first in the left ear. No support was found for

"echoic storage" or a passive, sensory image from which information could be extracted. In the second experiment silent spaces were added to the six-digit list so that it took 1 second for presentation. Once again the shorter lists were recalled better. Of greater importance was the finding that lists containing spaces resulted in greater recall accuracy and that spacing the digits facilitated recall accuracy less on the longer lists. Some findings opposing Neisser's "echoic storage" include a tendency toward primacy in recall ("echoic storage" should result in recency effects); and since spacing between digits lengthened the time of presentation, it should have been detrimental to "echoic storage" resulting in poorer recall, but such was not the situation.

Gerver (1971) used shadowing and interpretation of a foreign language by trained professional conference interpreters as a means for examining the effect of variation in input rate on language interpretation performance. He found that as rate increased (from 95 to 164 wpm) the percent of words correct decreased much more rapidly for the interpreters than for the shadowers. Higher pause-to-speech ratios were maintained by the interpreters and increases in the rate-of-presentation had a significant effect on pause-to-speech ratios for both interpreters and shadowers. Shadowers were able to maintain a higher rate of output than the interpreters; rate-of-presentation was significant for both groups; and the interaction between output and rate was significant with the shadowers increasing their output at faster rates while the interpreters declined in their output at the faster rates. The findings of this interesting study were summarized by the author as follows:

The picture emerges of an information handling system which is subject to overload if required to carry out more complex processes at too fast a rate and copes with overload by reaching a steady state of throughput at the expense of an increase in errors and omissions. There is evidence that attention is shared within this system between the input message, processes involved in translating a previous message, and the monitoring of feedback from current output. Under

normal conditions, attention can be shared between these processes, but when the total capacity of the system is exceeded, less attention can be paid to either input or output if interpretation is to proceed at all. Hence, less material is available for recall for translation, and more omissions and uncorrected errors in output will occur [p. 184].

While more research could be given in support of the three major topic areas of attention research, it would not be as directly related as that which has been reviewed. The only conclusion which seems appropriate is that the nature of compressed speech and the technology which is now available for compressing speech [the CRCR NEWSLETTER of 15 February 1974 noted a new variable speed control which is relatively inexpensive and can be used with several common audio casettes] make it a potentially useful vehicle for exploring the nature and functions of attending and information processing in humans. Hopefully more and better research will be forthcoming in the near future.

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